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[Triaxial stellar systems following the $r^{1/n}$ luminosity law]Triaxial stellar systems following the $\mathbf{r^{1/n}}$ luminosity law: an analytical mass–density expression, gravitational torques and the bulge/disc interplay

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Accepted 0000 December 00. Received 0000 December 00; in original form 0000 October 00

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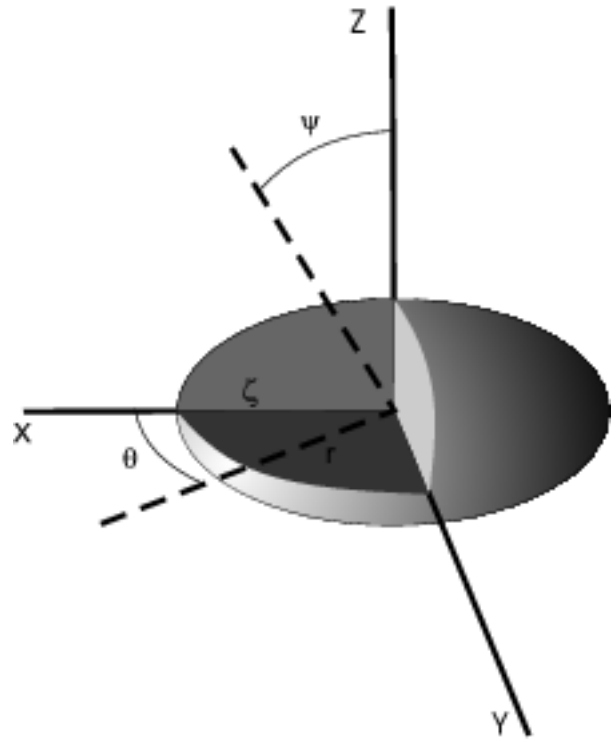
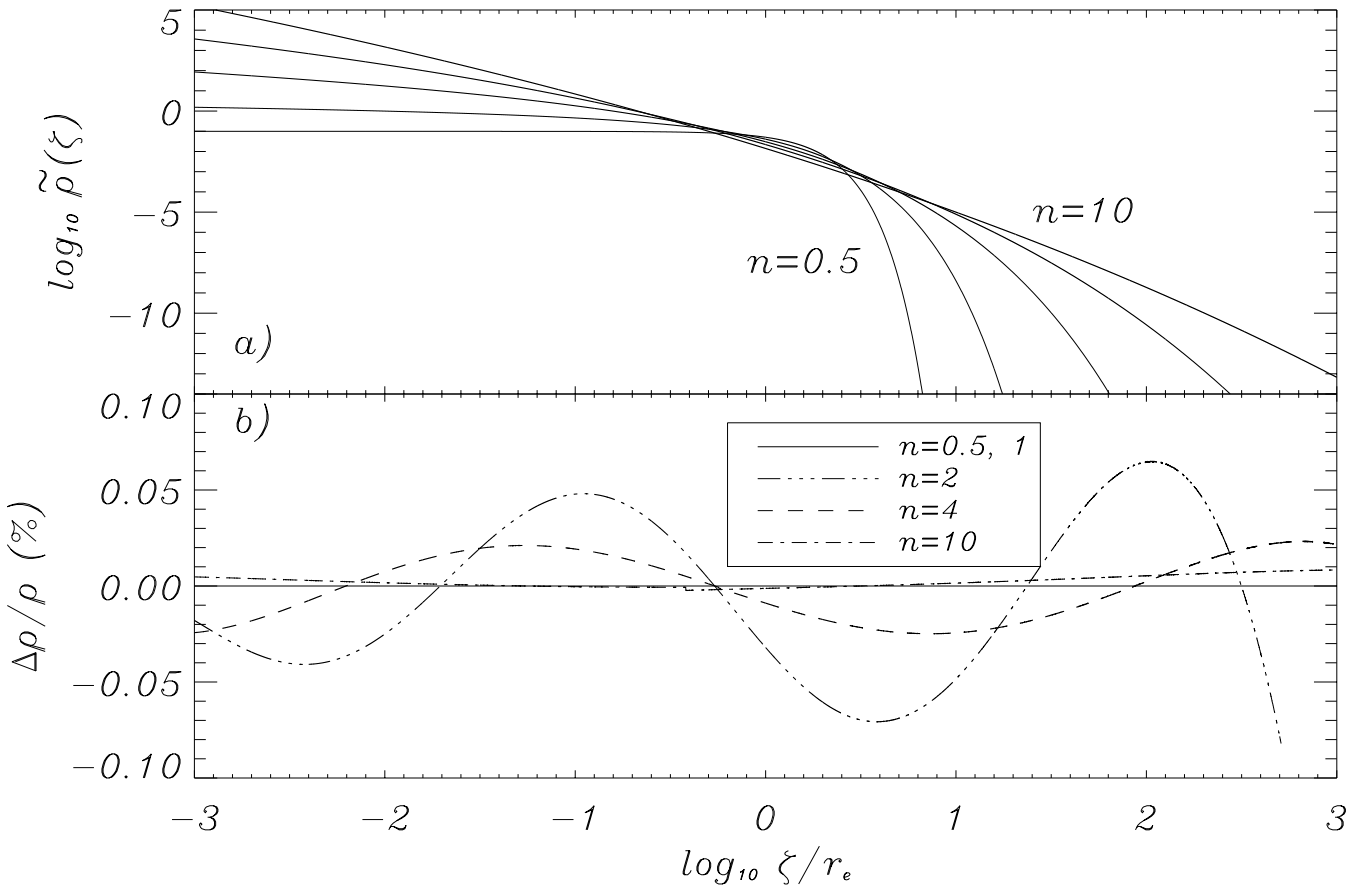
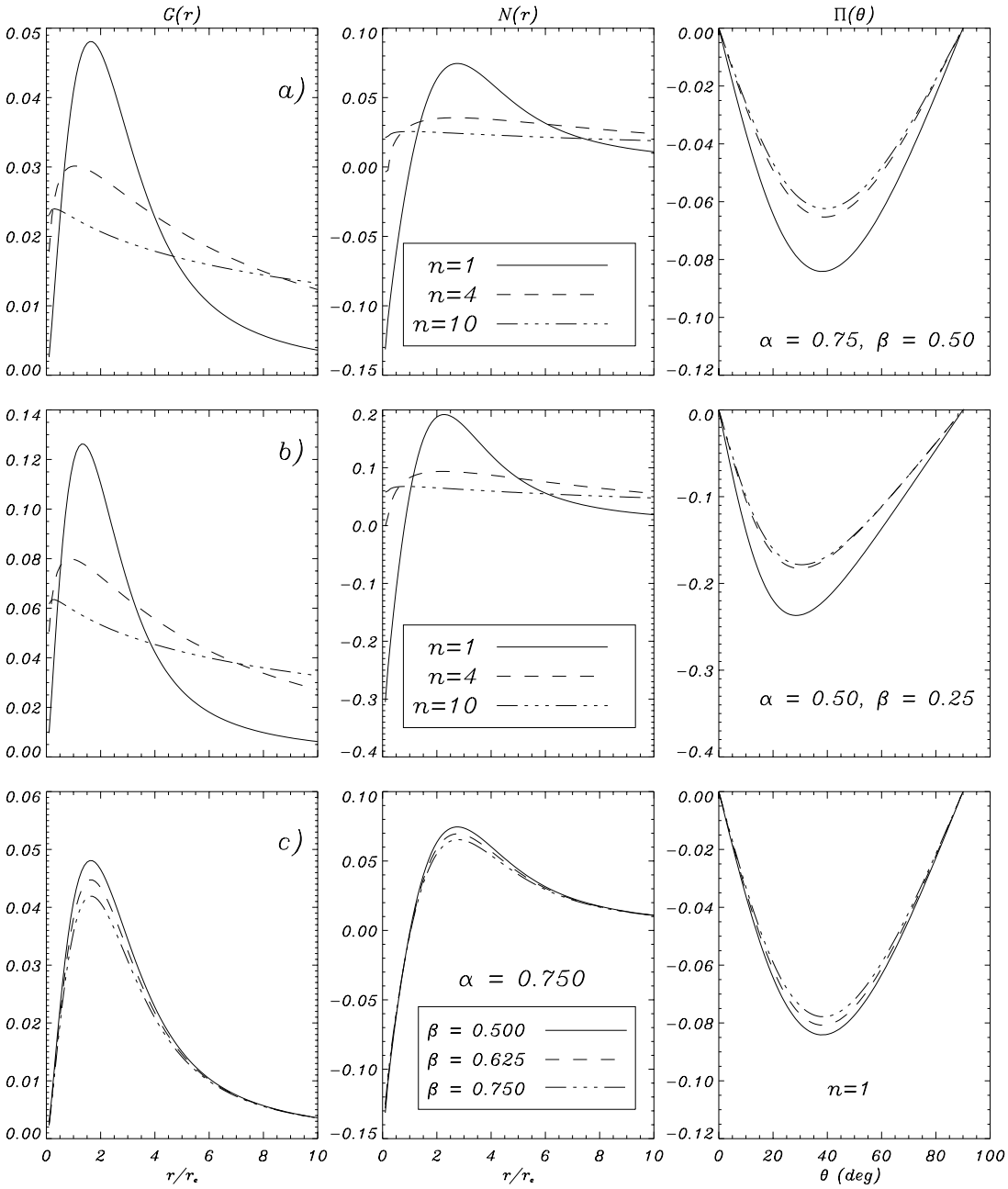
abstract

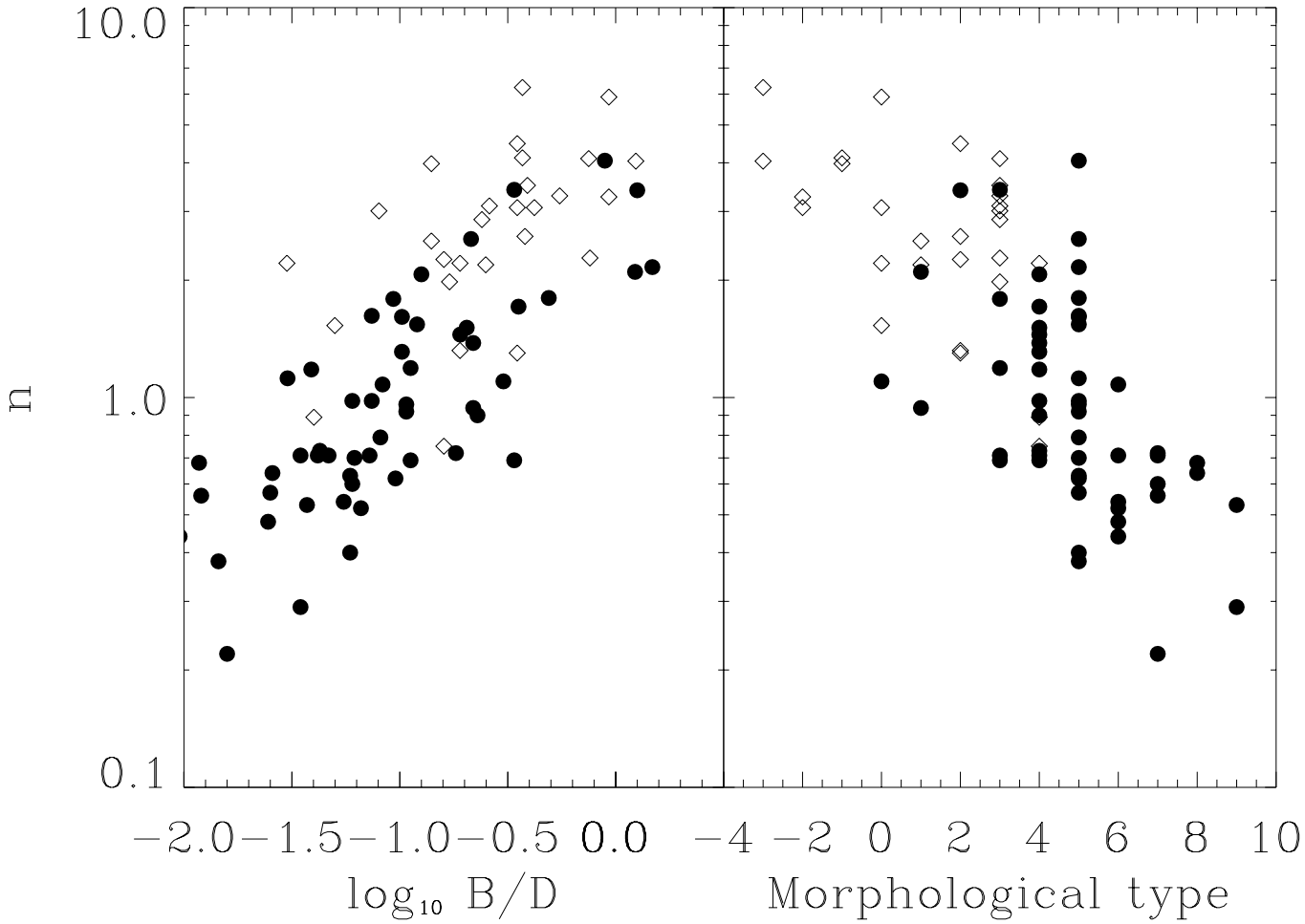
We have investigated the structural and dynamical properties of triaxial stellar systems whose surface brightness profiles follow the $r^{1/n}$ luminosity law – extending the analysis of Ciotti (1991) who explored the properties of spherical $r^{1/n}$ systems. A new analytical expression that accurately reproduces the spatial (i.e. deprojected) luminosity density profiles (error less than 0.1%) is presented for detailed modelling of the Sérsic family of luminosity profiles. We evaluate both the symmetric and the non–axisymmetric components of the gravitational potential and force and compute the torques as a function of position. *For a given triaxiality, stellar systems with smaller values of n have a greater non–axisymmetric gravitational field component.* We also explore the strength of the non–axisymmetric forces produced by bulges with differing n and triaxiality on systems having a range of bulge–to–disc ratios. The increasing disc–to–bulge ratio with increasing galaxy type (decreasing n) is found to heavily reduce the amplitude of the non–axisymmetric terms, and therefore reduce the possibility that triaxial bulges in late–type systems may be the mechanism or perturbation for non–symmetric structures in the disc.

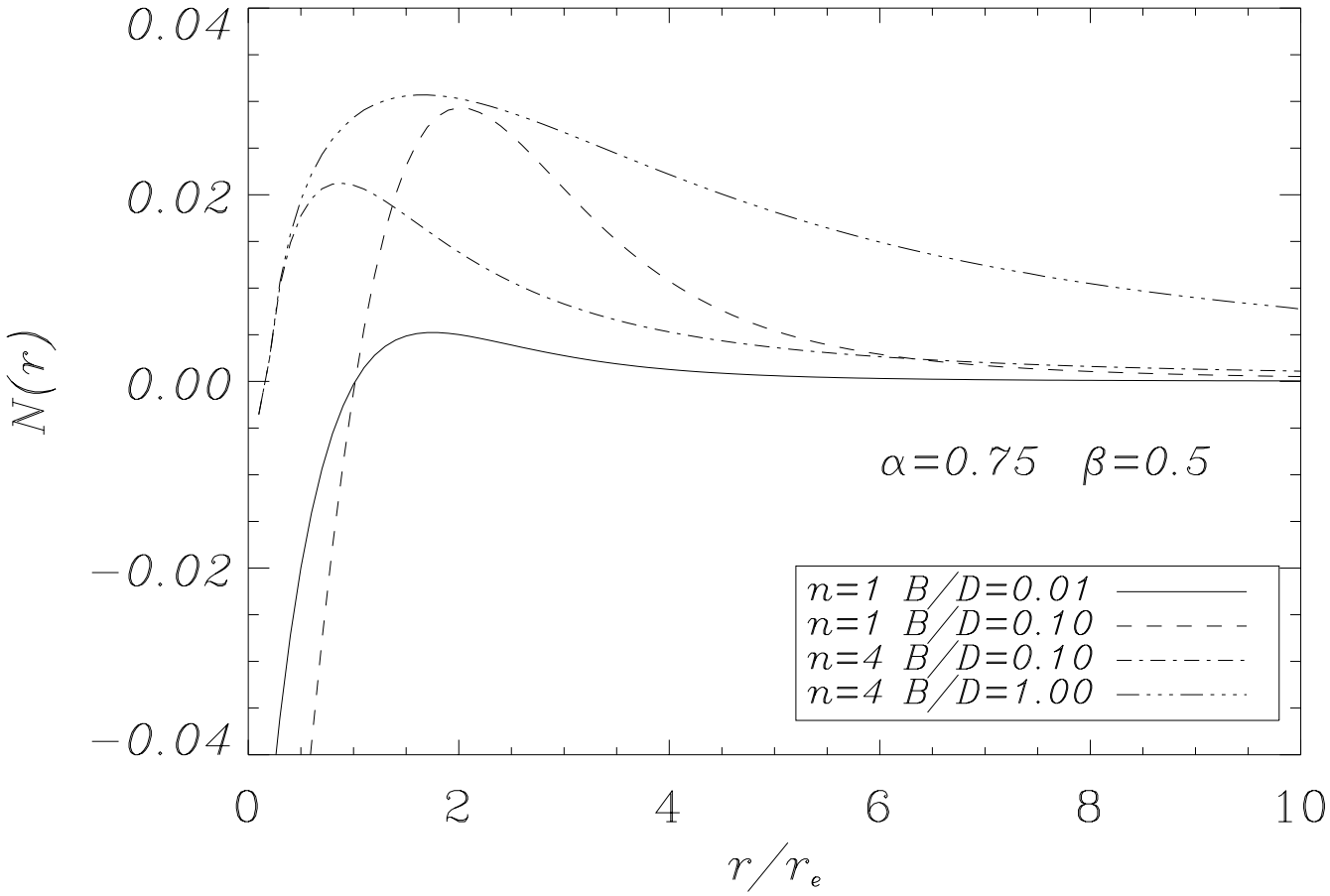
Using seeing–convolved $r^{1/n}$–bulge plus exponential–disc fits to the K–band data from a sample of 80 nearby disc galaxies, we probe the relations between galaxy type, Sérsic index n and the bulge–to–disc luminosity ratio. These relations are shown to be primarily a consequence of the relation between n and the total bulge luminosity. In the K–band, the trend of decreasing bulge–to–disc luminosity ratio along the spiral Hubble sequence is predominantly, although not entirely, a consequence of the change in the total bulge luminosity; the trend between the total disc luminosity and Hubble type is much weaker.

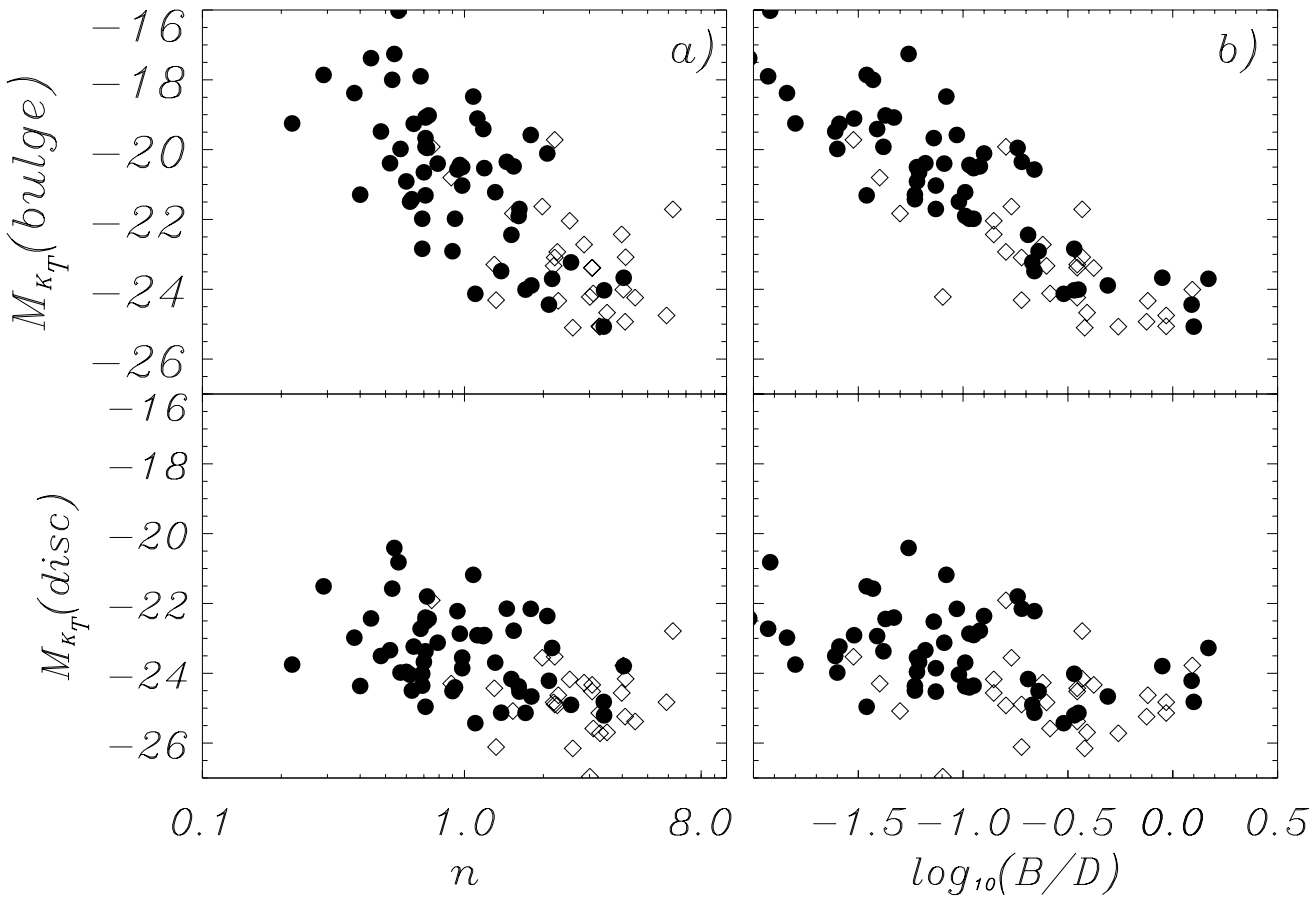

Z
ψ
ζ
X
θ
r
Y

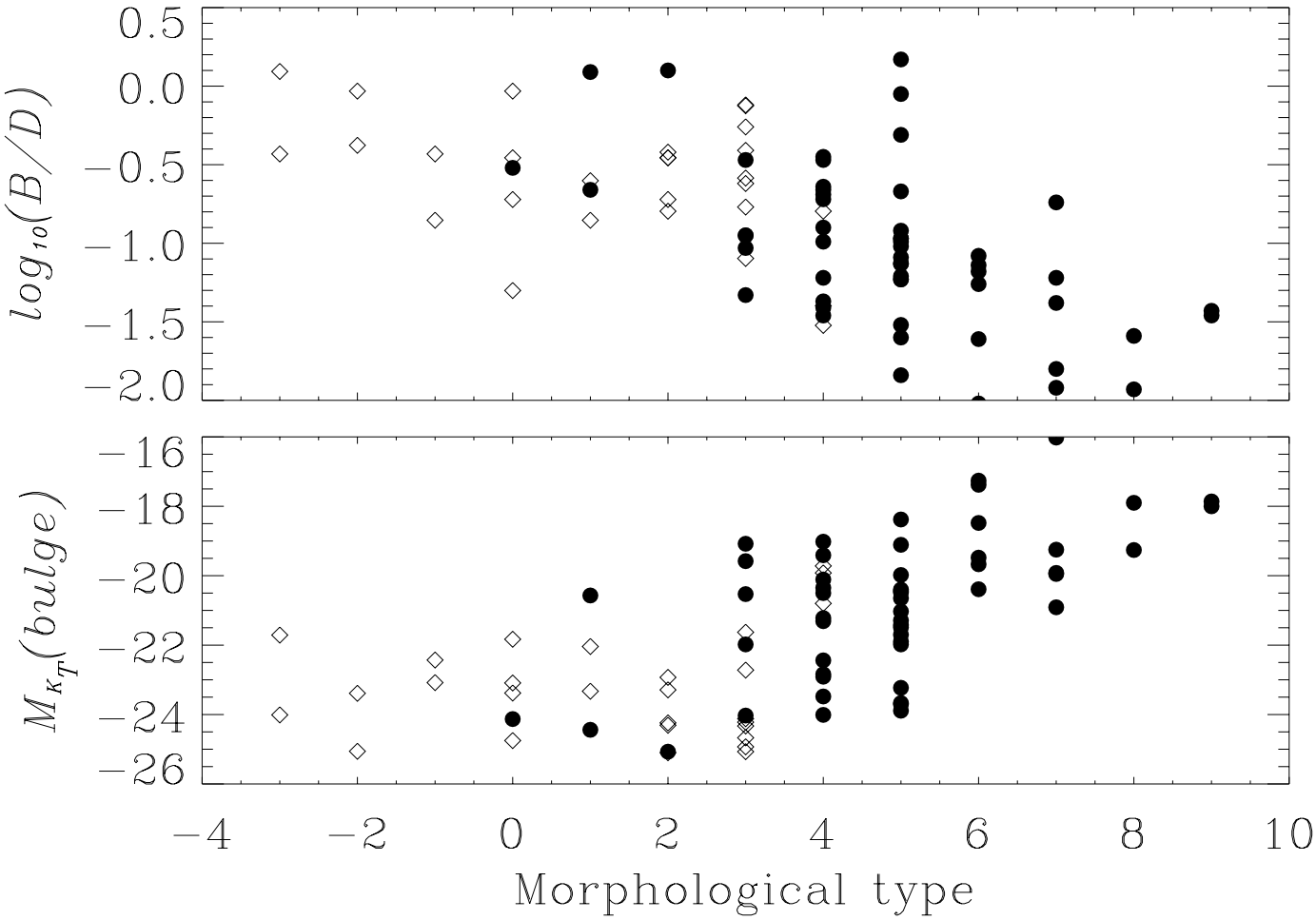

5
0
−5
−10
$\log_{10} \tilde{\rho}(\zeta)$
a)
n=10
n=0.5
0.10
0.05
0.00
−0.05
−0.10
$\Delta\rho/\rho$ (%)
b)
n=0.5, 1
n=2
n=4
n=10
−3
−2
−1
0
1
2
3
$\log_{10} \zeta/r_e$


G(r)
N(r)
Π(θ)
a)
b)
c)
n=1
n=4
n=10
α = 0.75, β = 0.50
α = 0.50, β = 0.25
α = 0.750
β = 0.500
β = 0.625
β = 0.750
n=1
r/r*
r/r*
θ (deg)


10.0
1.0
0.1
n
−2.0 −1.5 −1.0 −0.5 0.0
log10 B/D
−4 −2 0 2 4 6 8 10
Morphological type


0.04
0.02
0.00
−0.02
−0.04
N(r)
0
2
4
6
8
10
r/r_e
α=0.75 β=0.5
n=1 B/D=0.01
n=1 B/D=0.10
n=4 B/D=0.10
n=4 B/D=1.00


a)
b)
$M_{K_T}(bulge)$
$M_{K_T}(disc)$
−16
−18
−20
−22
−24
−26
0.1
1.0
8.0
n
−1.5
−1.0
−0.5
0.0
0.5
$log_{10}(B/D)$


0.5
0.0
−0.5
−1.0
−1.5
−2.0
$log_{10}(B/D)$
−16
−18
−20
−22
−24
−26
$M_{K_T}(bulge)$
−4
−2
0
2
4
6
8
10
Morphological type